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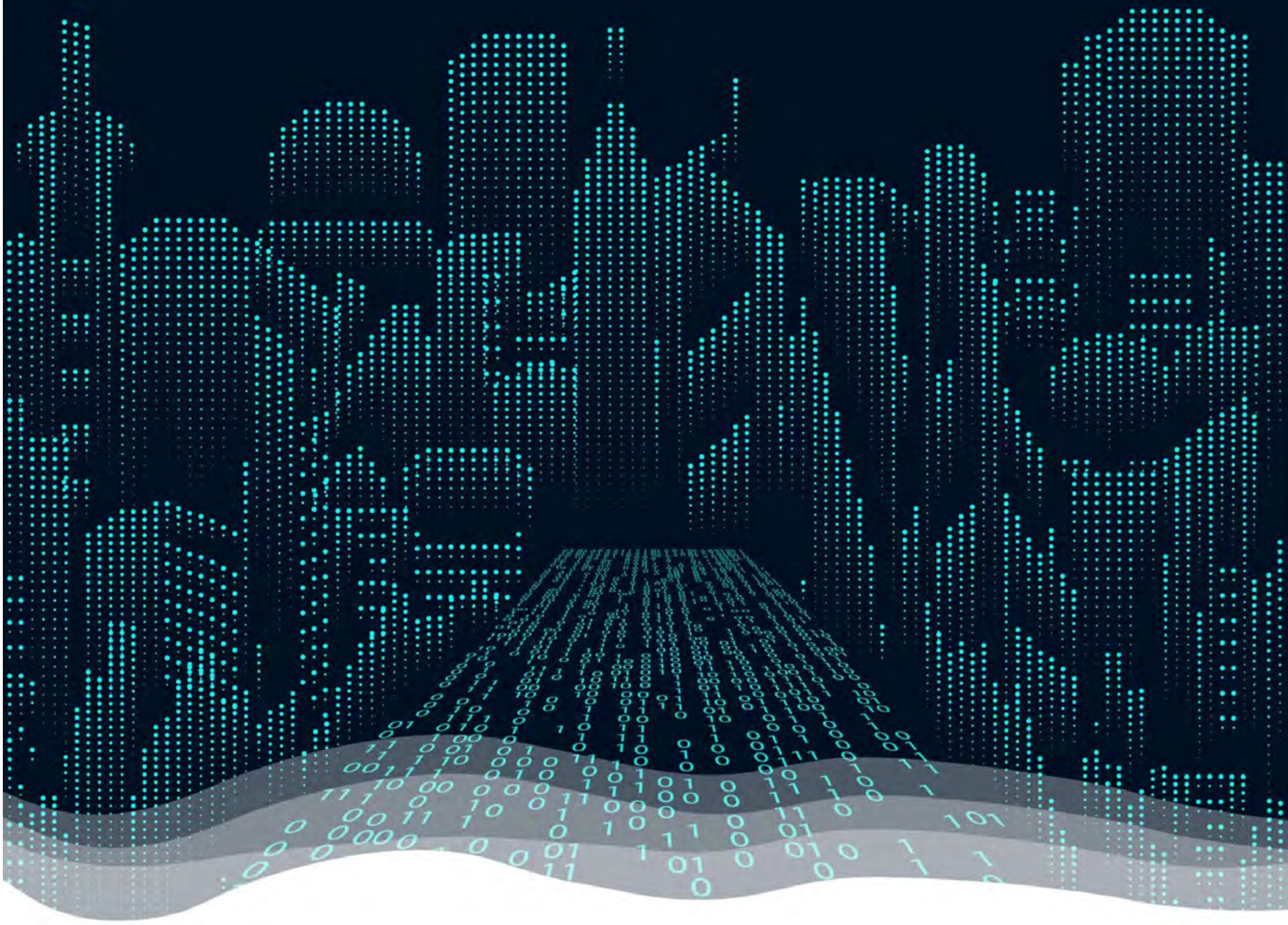

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Findings in the calculation of solar irradiance in urban areas using several GIS tools

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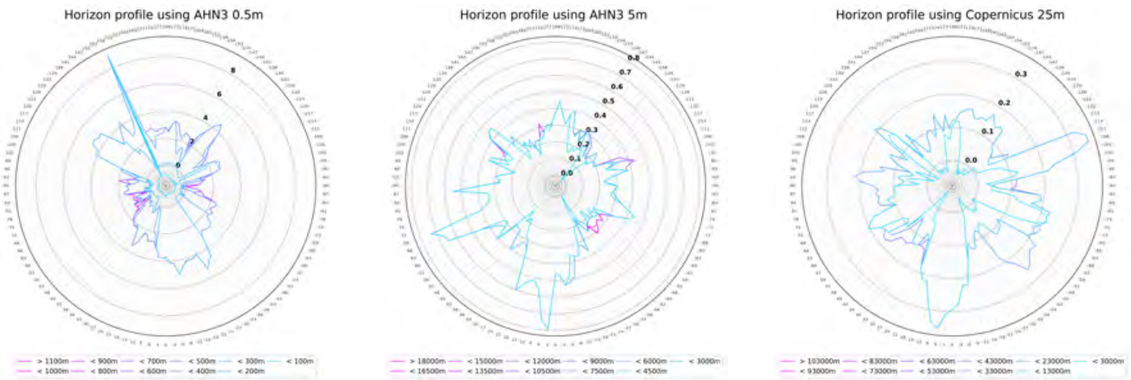
***Abstract** – Current GIS software offer tools to perform the solar irradiance calculations. However, these computations based their work on data assumptions or generalisations to speed up their processing time. In this work, a method is shown to perform the calculation using very high and very low spatial resolution open datasets. The results show that there too detailed raster data like 50cm horizontal spatial resolution DSM does not improve the calculations compared to lower resolution datasets.*

In 2018, at least 55% of the global population lives urban areas and by 2023 it will increase to 60% (United Nations, 2018). Wrong quantification of the current and expected energy demand of buildings, will lead to erroneous decisions and misguided planning for energy supply. Solar gains play a major role in any energy demand simulation. For that reason, it is important to have a precise calculation of the solar radiation for a given area of interest. This work shows a method to perform the solar radiation using raster open datasets in the Netherlands and three GIS software tools. Liang et al. (2020) proposes a method to extend the GRASS GIS r.sun model by feeding it with 3D data including 3DCity models and photogrammetric meshes, Gianelli (2021) performs a solar analysis on buildings of favelas in Sao Paulo using several software tools and different input format datasets (raster and 3D semantic City Models)

The proposed method includes the use of digital surface models (DSM) in a raster format at different spatial resolutions. Our purpose is to test the influence of the spatial resolution in the solar irradiation simulations. We use raster-based DSM with different spatial resolutions, the Netherlands current elevation database (Actueel Hoogtebestand Nederland – AHN) at 50cm and 5m (stuurgroep AHN, 2019) and the European Digital Elevation Model (EU-DEM) (European Environment Agency (EEA), 2016). The study is located at the weather station of Heino in The Netherlands. Since we are working with several data sources and different spatial resolutions, we analyse the horizon profile from the weather station at a systematic interval distance to identify changes in the Orography. Once the right distance is found, we evaluate the influence of large distance obstacles in the horizon. The resulting input DSM is used as an input for several Solar Irradiance GIS software tools, this is the case of ArcGIS (esri, 2023), GRASS (Hofierka et al., 2007), SAGA GIS (Conrad, 2010). Simulation results are compared against typical year data open data available by the open climate project (Lawrie & Crawley, 2019) which offers weather data for the whole planet.

First, we calculate the sky view for the very height resolution DSM. **Error! Reference source not found.** shows the resulting sky view of each of the input datasets, from left to right the spatial resolution decreases. Each of the plots contains the same colour palette going from cyan (closest) to magenta (furthest). For the point of interest, the highest obstacle is in less than 200m with an azimuth of 156º and an elevation angle of 9º (**Error! Reference source not found.**A). **Error! Reference source not found.**B and **Error! Reference source not found.**C give show the orography of the up to 18Km and 103Km for the AHN3 5m and Copernicus datasets respectively. For the latter two plots, we remove from the analyses the area covered by the very-high resolution DSM. This indicates that the weather station is not affected by far away obstacles.

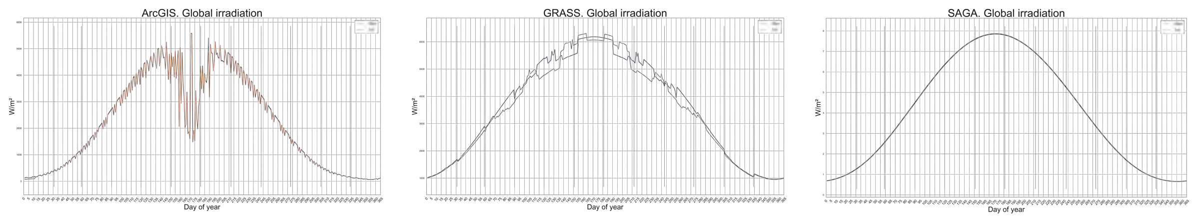


A **B** **C**

Figure 5. Horizon profile (Sky view) for the input datasets.

Since there is no change from 1.200m (**Error! Reference source not found.**A), we decided to use as input DSM for the solar irradiance calculations a square raster with a side size of 1200m. We decide to test the influence of the spatial resolution in the calculations, for that reason we resample the 50cm dataset to 1m, which is still a very-high resolution dataset.

Error! Reference source not found. shows the year profile for each of the simulation tools for a typical year in the selected spatial resolutions.



A B C

Figure 6. Daily global irradiation by software tool

The vertical thicker lines in **Error! Reference source not found.** indicate the starting day of the month. Despite of ArcGIS, which only request the DSM, we used as input dataset for the Linke turbidity factor the dataset published by Solar radiation Data (SoDa, 2010). Since this is a very low-resolution dataset of 1/12°, we extract the value at each pixel location of the input DSM so there is no difference in the input data resolution when the software tools perform their calculations.

Error! Reference source not found. shows the line plot for the global irradiance values of the weather station against the results obtained from the simulation tools.

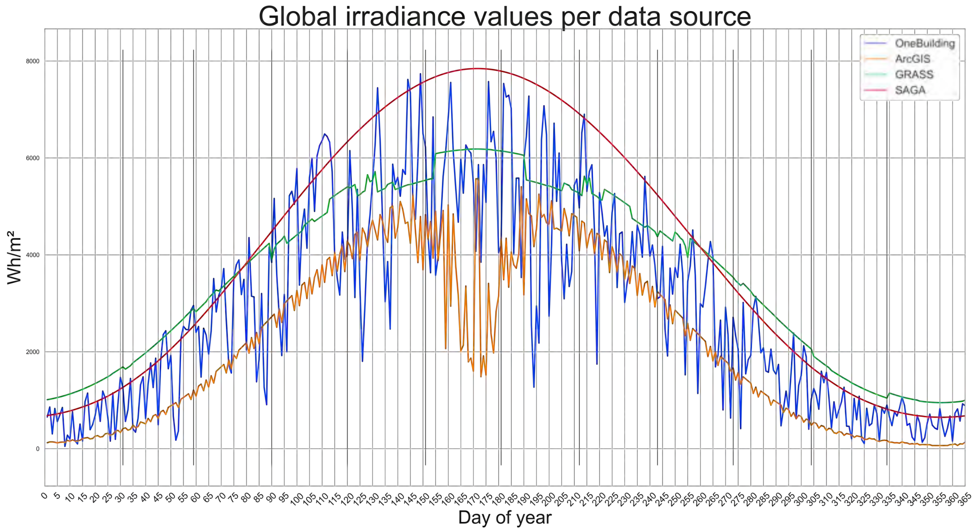


Figure 7. Daily global irradiance values for the weather station and simulation tools

The results obtained by the calculation using ArcGIS shows that there is practically no difference between the results obtained using 50cm or 1m spatial resolution DSMs, which is not the case of the other two simulation tools. ArcGIS values are the lowest one of the three while SAGA produces the highest values. It is possible to see as well that SAGA do not consider weather data for its calculations since the results are quite normalised, not showing the normal cloud behaviour in the sky.

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